1. An acoustic pyrometer, comprising:

means for generating an acoustic signal with a high amplitude sudden onset;

means positioned adjacent said signal generating means for detecting the onset of said acoustic signal in said signal generating means and generating a first electrical signal corresponding in time to said onset of said acoustic signal in said signal generating means;

means positioned across a space of known distance from said signal generating means for receiving acoustic signals from said space and for generating electrical signals corresponding to amplitude and frequency of said acoustic signals received in said receiving means; and

means for processing said electrical signals from said receiver to distinguish the onset of said acoustic signal from background noise in said space as detected in said receiving means, and for comparing the time of said onset of said acoustic signal in said receiving means with said onset of said acoustic signal in said signal generating means to determine the transit time of said acoustic signal to traverse said space, and for calculating said temperature of said gas in said space based on said transit time.

2. An acoustic pyrometer as defined in claim 1, wherein:

said signal processing means includes a time of flight module for determining the transit time of said acoustic signal to traverse said space.

3. An acoustic pyrometer as defined in claim 2, wherein said time of flight module produces a distinct differentiation between background noise and said onset of said acoustic signal in said receiving means, said time of flight module including:

a digital prefilter for modifying said signal received in said receiving means to a modified signal having an increased ratio of amplitudes of said acoustic signal to said noise; and

a stochastic model of said signal for determining the time of onset of said acoustic signal in said receiving means.

4. An acoustic pyrometer as defined in claim 3, wherein:

said digital pre-filter includes a prediction error filter that measures N consecutive samples of said signal received in said receiving, and predicting what the $N+1^{th}$ signal will be from the previous N samples, then measuring said $N+1^{th}$ sample and subtracting said predicted $N+1^{th}$ signal from said actual measured $N+1^{th}$ signal

value to produce a small amplitude modified signal having more characteristics of said acoustic signal from said signal generator.

5. A method of measuring the average gas temperature along a line through an open space, comprising:

generating an acoustic signal with a high amplitude sudden onset;

detecting said onset of said acoustic signal and generating a first electrical signal corresponding in time to said onset of said acoustic signal;

propagating said acoustic signal across a space of known distance to a receiver;

generating electrical signals in said receiver corresponding to amplitude and frequency of said acoustic signals received in said receiver;

processing said electrical signals from said receiver to produce a distinct differentiation between background noise and said acoustic signal in said receiver;

comparing the time of onset of said acoustic signal in said receiver with said onset of said acoustic signal in said signal generator to determine the transit time for said acoustic signal to traverse said space; and

calculating said temperature of said gas in said space based on said transit time.

6. A method as defined in claim 5, wherein said acoustic signal generating step includes:

closing an exit throat in an enclosed space with a slidable plug slidably sealed in said throat;

charging said enclosed space with pressurized gas to create a pressurized gas volume;

accelerating said plug in said throat and then withdrawing said plug at high speed from said throat to effect complete opening of said throat in a short time to release said pressurized gas volume through said throat in a burst to produce said acoustic signal with a fast rise time from zero amplitude to an amplitude greater than 170db in a less than 5ms.

7. A method as defined in claim 5, wherein said electrical signal processing includes:

digitally pre-filtering said acoustic signals received in said receiver to facilitate differentiation between background noise in said open space and said acoustic signal so as to locate the beginning of said acoustic signal in said background noise.

8. A method as defined in claim 7, wherein said prefiltering includes:

a) measuring N consecutive samples of said signal received in said receiver;

b) predicting what an N+1th signal will be from the previous N samples;

c) measuring said N+1th sample to obtain an actual measured value of said N+1th sample;

d) subtracting said predicted N+1th signal from said actual measured N+1th signal value; and

e) repeating steps a)-d) with each new sample taken to produce a small amplitude modified signal having more characteristics of said acoustic signal from said signal generator.

9. A method as defined in claim 5, further comprising:

forming a stochastic model having two or more states, each state behaving like a stationary random variable that produces uncorrelated white Gaussian noise, said model able to move from state to state as time progresses;

said model having a first state representing said background noise of said filtered signal without said acoustic signal imposed, and a second state acting like said acoustic signal;

normalizing said filtered signal to zero-mean as part of said pre-filtering process,

estimating the statistical variance of the samples from said first state using signal samples known to contain only background noise with said acoustic signal absent, using samples that occur before generation of said acoustic signal by said acoustic signal generator;

estimating the statistical variance of samples from said second state from samples located directly around said sample with maximum amplitude in the filtered signal;

determining the most probable time for the shift from said first state to said second state, and the most probable time for the arrival of said acoustic signal, by labeling each time index with a state using said filtered signal from said receiver and said stochastic.

10. A method as defined in claim 5, further comprising:

validating temperature measurements by one or more of the following techniques:

a) listening for a period of relative quiet inside the boiler to take a measurement and taking said temperature measurement only when a predetermined noise threshold is not exceeded;

b) comparing the time of arrival of signals detected by said receivers to the time of generation of signals in the signal generator and discarding as invalid acoustic signals is found to lie in very close proximity to the beginning or end of the sampled interval, and signals whose amplitude is found to be small compared to the filtered background noise;

c) temperature measurements outside a predetermined range deemed to be reasonably expected inside a boiler are discarded as invalid;

d) comparing the most recent measured temperature with a validated base temperature and discarding said most recent measured temperature if it is outside a reasonable range of likely as presumptively invalid, said validated base temperature being selected from 1) the previous several measured temperatures taken within a predetermined measuring period, and 2) a baseline temperature measurement for use at system start-up or after the expiration of a validation period in which no valid temperature measurements were taken, said baseline temperature being an average of a number of temperature measurements taken in rapid succession.

11. A method as defined in claim 5, further comprising:

propagating said acoustic signal across the full width of a pendant tube bank to produce a full width cross-pendant measurement.

12. A method as defined in claim 5, wherein:

said acoustic signal is produced in a signal generator placed outside an interior wall in a boiler nose in said boiler and transmitted through a long output barrel extending through a heated space behind a tube wall of said bull nose and opening into the interior of said boiler through said bull nose tube wall;

said receiver is placed in the top end of a cable drop tube extending through the top tube wall, through the "penthouse" and through the top wall of said boiler;

whereby said signal generator is isolated from the hot interior chamber behind the boiler nose and said receiver is protected from excessive temperatures inside said "penthouse" while producing valuable temperature data about the entrance plane into pendant tube banks inside said boiler.

13. A method as defined in claim 5, wherein:

said acoustic signal propagates from said signal generator to said receiver by way of a tube opening in a bull nose tube wall of said boiler;

said receiver being mounted on the cool side of a partition across said bull nose ;

whereby said receiver receives signals usable to produce valuable information about gas temperatures in the vicinity of said bull nose while remaining protected from heat in said bull nose.

14. An acoustic pyrometer for measuring the average temperature of gas along a path across a space of known distance, comprising:

an acoustic signal generator for generating an acoustic signal with a peak amplitude of at least about 170db and a rise time from zero to maximum amplitude of less than about 10 ms;

a detector positioned adjacent said signal generator for detecting the onset of said acoustic signal in said signal generator and generating a first electrical signal corresponding in time to said onset of said acoustic signal in said signal generator;

a receiver positioned across said space from said signal generator for receiving acoustic signals from said space and for generating electrical signals corresponding to amplitude and frequency of said acoustic signals received in said receiver; and

a signal processor for processing said electrical signals from said receiver to distinguish the onset of said acoustic signal from background noise in said space as detected in said receiver, and for comparing the time of said onset of said acoustic signal in said receiver with said onset of said acoustic signal in said signal generator to determine the transit time of said acoustic signal to traverse said space, and for calculating said temperature of said gas in said space based on said transit time, said signal processor processing said electrical signals from said receiver to produce a distinct differentiation between background noise and the onset of said acoustic signal in said receiver.

15. An acoustic pyrometer as defined in claim 14, wherein:

said signal processor includes a time-of-departure module, a time-of-flight module, and a temperature calculation module;

said time-of-departure module locates the beginning of the acoustic signal from the acoustic signal generator;

said time-of-flight module analyses the signal received by said receiver microphone to facilitate differentiation between background noise and said acoustic signal so as to locate the beginning of the acoustic signal in the background noise; said time of flight module having a digital prefilter for modifying said signal received in said receiver to produce a modified signal having an increased ratio of the acoustic signal amplitude to the noise amplitude, and creates a stochastic model of said signal consisting of two or more "states", each state behaving like a stationary random variable that produces uncorrelated white Gaussian noise and able to move from state to state as time progresses for determining the time of onset of the acoustic signal in said receiver;

said modified signal from said receiver and said model are used together to label each time index with a state and detect the transition between two states by determining the most probable time for the shift from one state to the other state, thereby indicating the arrival of said acoustic signal.

said temperature module calculates the temperature of the open space between the signal generator and the receiver based on a known path length through said open space and by said measured transit time of said acoustic signal from said signal generator to said receiver as a function of temperature.

16. An acoustic pyrometer as defined in claim 14, wherein said acoustic signal generator includes:

a main cylinder having front and rear opposed ends and an axial opening in each end;

a partition in an intermediate portion of said cylinder dividing said cylinder into front and rear chambers, and an axial opening in said partition communicating between said chambers;

a rear cylinder attached to said rear cylinder end around said rear axial opening and communicating therethrough with said rear chamber;

a piston assembly having an intermediate piston in said rear chamber, and a rear piston in said rear cylinder;

a seal assembly connected to said piston assembly and movable therewith, said seal assembly having a front plug and a front seal coacting with said front plug to seal said front end axial opening, and an intermediate seal plugging said axial opening in said partition;

said front seal is mounted on said front plug and is normally disposed on said front plug in a bore forming part of said front axial opening and is movable axially with said front plug;

a pneumatic operating system for charging said rear chamber of said main cylinder with gas at a first high pressure and for charging said rear cylinder with gas at a second high pressure, said pneumatic operating system including a coupling for connection to a source of gas pressure and a remotely operated vent to allow said pressurized gas in said rear cylinder to escape, thereby reducing forwardly directed forces on said intermediate piston in said rear chamber exerted by pressurize gas on said rear piston, below rearwardly directed forces exerted by pressurized gas in said forward chamber against said intermediate seal.

17. An acoustic signal generator for generating an acoustic signal with a high amplitude, sudden onset, comprising:

a main cylinder having front and rear opposed ends and an axial opening in each end;

a partition in an intermediate portion of said cylinder dividing said cylinder into front and rear chambers, and an axial opening in said partition communicating between said chambers;

a rear cylinder attached to said rear cylinder end around said rear axial opening and communicating therethrough with said rear chamber;

a piston assembly having an intermediate piston in said rear chamber, and a rear piston in said rear cylinder;

a seal assembly connected to said piston assembly and movable therewith, said seal assembly having a front plug and a front seal coacting with said front plug to seal said front end axial opening, and an intermediate seal plugging said axial opening in said partition;

said front seal is mounted on said front plug and is normally disposed on said front plug in a bore forming part of said front axial opening and is movable axially with said front plug;

a pneumatic operating system for charging said rear chamber of said main cylinder with gas at a first high pressure and for charging said rear cylinder with gas at a second high pressure, said pneumatic operating system including a coupling for connection to a source of gas pressure and a remotely operated vent to allow said pressurized gas in said rear cylinder to escape, thereby reducing forwardly directed forces on said intermediate piston in said rear chamber exerted by pressurize gas on said rear piston, below rearwardly directed forces exerted by pressurized gas in said forward chamber against said intermediate seal.

18. An acoustic signal generator as defined in claim 17, wherein:

said vent includes a restricted orifice through which gas is allowed to escape from said rear cylinder at a preselected slow rate;

whereby a gas cushion remains in said rear cylinder to decelerate said piston assembly and minimize damage to said piston assembly.

19. An acoustic signal generator as defined in claim 19, wherein:

said front seal is of smaller diameter than said intermediate seal.

20. A method of generating an acoustic signal having a sharp, high amplitude onset, comprising:

plugging an opening into a cavity within a body by positioning a plug in said opening, said opening communicating through said body between said cavity and external space outside said cavity;

pressurizing gas in said cavity;

accelerating said plug to high speed prior to unplugging said opening; and

unplugging said opening by moving said valve at high speed from a fully plugged position to a fully unplugged position and releasing said pressurized gas suddenly from said cavity to said external space.

21. A method as defined in claim 20, wherein said valve accelerating step comprises:

opening a port between said cavity; and

exerting elevated gas pressure suddenly against a large diameter piston connected to said valve.

22. A process of determining the arrival time of an acoustic signal propagated through a noisy environment and detected in a receiver, comprising:

digitally pre-filtering said acoustic signals received in said receiver to facilitate differentiation between background noise in said open space and said acoustic signal so as to locate the beginning of said acoustic signal in said background noise; said prefiltering includes, a) measuring N consecutive samples of said signal received in said receiver, b) predicting what an $N+1^{th}$ signal will be from the previous N samples, c) measuring said $N+1^{th}$ sample to obtain an actual measured value of said $N+1^{th}$ sample, d) subtracting said predicted $N+1^{th}$ signal from said actual measured $N+1^{th}$ signal value; and,

e) repeating steps a)-d) with each new sample taken to produce a small amplitude modified signal having more characteristics of said acoustic signal from said signal generator;

forming a stochastic model having two or more states, each state behaving like a stationary random variable that produces uncorrelated white Gaussian noise, said model able to move from state to state as time progresses, said model having a first state representing said background noise of said filtered signal without said acoustic signal imposed, and a second state acting like said acoustic signal; normalizing said filtered signal to zero-mean as part of said pre-filtering process; estimating the statistical variance of the samples from said first state using signal samples known to contain only background noise with said acoustic signal absent, using samples that occur before generation of said acoustic signal by said acoustic signal generator; estimating the statistical variance of samples from said second state from samples located directly around said sample with maximum amplitude in the filtered signal; and determining the most probable time for the shift from said first state to said second state, and the most probable time for the arrival of said acoustic signal, by labeling each time index with a state using said filtered signal from said receiver and said stochastic.

23. A method of centering a fireball in a boiler furnace, comprising:

separately actuating in rapid succession two signal generators placed in opposite sides of a fire box, and receiving signal produced by said signal generators in two receivers positioned opposite each other and on a plane transverse to a plane through both said signal generators;

analyzing signals received in said receivers to detect non-uniform temperatures along sides of said firebox;

adjusting the orientation of burners in said firebox to shift the fireball toward the center of the firebox.